Applied Technology and Research for Solving Rio Grande Basin Water Problems

As described in the previous sections, the water problems in the Rio Grande Basin can be characterized by insufficient quantity of high quality water to meet the existing and future demands of the basin. The lack of water in turn leads to competition for existing supplies and consequent conflict. Complicating this picture are key uncertainties in the overall water budget, in the location and quantity of adequate water supplies, and most of all in the response of the hydrologic system to natural and man-made stresses. This section proposes one approach for relating existing technology and future research to the solution of the water problems in the Rio Grande Basin. This approach would, in general, be applicable to other basins in the US and elsewhere.

Given the fundamental problem of insufficient water supply for the existing demand, there are two basic solutions - create more water or better manage the existing supplies.

Within the Rio Grande Basin there are limited possibilities for creating new water. For example, there are minimal available supplies of saline water that could be the target of desalinization options. Cloud seeding would be another example of 'creating' more water. However the new water would be at the expense of other adjacent or nearby basins. Therefore this discussion focuses on developing and applying better techniques for managing the existing supplies and managing and treating the uncertainties associated with these supplies.

In order to identify and define a solution to water management problems it is useful to highlight the main attribute of the problem, interdependence. Interdependence refers to all aspects of the water management problem. For example, interdependence is evident in the relation among sources of water. That is, streams both receive water from and contribute water to ground water and therefore changes in stream flow have the potential of affecting the use of groundwater resources. On the other hand, pumping of groundwater can reduce stream flow. In addition, land use can affect runoff and recharge and in turn the amount and type of available water affects land use. Certainly the ecological health of a basin is dependent on the water resources and the water resources are in turn dependent on healthy ecosystems. Interdependence is also the key descriptor of the relation between water and people and their livelihoods as well. Lack of sufficient water limits certain types of activities such as development and certain kinds of activities limit the available water supply, i.e. activities that pollute the water. Interdependence is also an attribute that describes the competing and conflicting desires people have for water use and distribution. For example, solutions for supplying water to one party often result in problems in supplying water to another party. The next key attribute of water management is that it involves large, complex, and incompletely known natural systems. We must make decisions in light of the fact that we will never have a complete understanding of these systems. For example, aquifer properties will never be known with certainty, future precipitation patterns and amounts are uncertain, and geometry and flow of surface water features are complex and ever changing.

Next realize that water management involves making decisions about water use based on needs, values, and desires in light economic realities and scientific knowledge and in the face of scientific uncertainty. So the question we must answer is what can science and technology bring to the table to address this complex problem will all of its constraints and attributes?

First we believe that simulation technology and computational engines are finally reaching the point that basin scale models that include all of the interdependencies listed above can be constructed. We can estimate regional circulation and precipitation patterns of complex and heterogeneous terrains, we can simulate future changes in these patterns and most important we can couple them to stream water flow and groundwater infiltration and recharge. It is now possible to build basin-scale detailed, coupled surface and groundwater flow models that also address the fate and transport of contaminates. In addition, functional relationships can be built in that describe the interdependence of the ecological system to the water systems and their relation to land use. These models in turn can be coupled with economic models to describe relationships between peoples livelihoods and water resource management.   Further the coupling of these models can be done dynamically, allowing for the investigation of potential effects of natural and man-made stresses to the water system. It is even possible to define the desires and needs of all of the water users (man as well as the natural system) and automatically search for management solutions that meet these needs.

Second, the results of the simulation tools mentioned above have little value unless they address the uncertainties associated with the water system. In the absence of the treatment of uncertainty, management decisions are not only made at risk, they are made without knowing the risks. Furthermore, the treatment of uncertainty is key to defining adequate monitoring and characterization efforts as well as defining future research needs.   Monitoring, characterization studies, and basic research can all be thought of as means to reduce uncertainty. Thus, if management decisions do not recognize uncertainty, then there is no need to reduce uncertainty. Techniques for quantifying and propagating model and parameter uncertainty are available and could be applied to dynamic simulations used for water management. In addition, decision analysis tools including sensitivity and data worth analysis exist that could be coupled with these complex dynamic simulation tools. And finally, we have shown that simulation results can be used to relate basic research needs to management decisions and that these research needs can be quantitatively prioritized.

The coupling of simulation models and decision support tools with real-time monitoring of the constantly changing basin properties will help water managers make the critical decisions that will be necessary to efficiently utilize and conserve the water resources of the basin. On a real-time basis, water mangers will be able to accurately predict and understand the consequences of their decisions. As the demand for the limited supply of water increases, the use of decision tools based on simulation models will become critical to the planners and regulators of water resources.